Indian J. Fish., 60(2) : *43-47, 2013*

Evaluation of multispecies marine fishery in West Bengal, India using diversity indices

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ABSTRACT

The effective management and conservation of ecosystems rely greatly on the understanding of spatial and temporal distributions of the fish community, ecological variables and fishing activity. The information on landings for all species by commercial fisheries can facilitate analysis of species diversity and distribution patterns. This paper attempts to assess the marine fishery in West Bengal, with emphasis on the diversity with special regard to the variation in quantity of fish caught during different seasons. During this period, a total of 154 different species of fish and shellfishes were landed along the West Bengal coast among which, demersal species were highest in number (65), followed by pelagic species (59). Only two or three groups were dominant in different seasons. During the first (January – March) and fourth (October – December) season, the dominant groups were Bombayduck, croakers and prawns. While, in the third (July – September) season, the dominant species were hilsa shad followed by Bombayduck and croakers. For assessing the diversity of fisheries in West Bengal, Simpson's index and Shannon's index were calculated from the season-wise estimated marine fish landings for the period 2007-2010. The values of Simpson's index varied from 0.06 to 0.37, the lowest recorded in first season of 2009 and highest in third season of 2007. The highest value was mainly because of the landings of a single species, the hilsa shad.

Keywords: Biodiversity, Multi-species marine fishery, Shannon's index, Simpson's index, West Bengal

Introduction

The northern subsystem (north-east coast of India) consists of the maritime states of West Bengal and Orissa, which is dominated by estuarine influence caused by drainage of freshwater and silt (Reemtsma *et al*., 1993). The overall nutrient levels are generally high along the system, but this is not reflected in high primary and secondary production (Dwivedi, 1993). However, productivity along the east coast is sufficient to support large subsistence and industrialised fishing sector (Vivekanandan and Krishnakumar, 2010).

The coastal area of West Bengal stretches between the mouths of rivers Herobhanga or Harinbhanga on the Indo-Bangladesh border in the east and Subanarekha in the west. Fishing activities in this zone provide economic sustenance and a source of livelihood to a cross-section of people in the lower Ganga deltaic region (Gupta, 2010**)**. The coastline of West Bengal spreads along the southern edge of its two maritime districts, 24 Parganas (south) and Purbo Medinipur (Fig. 1). The Purbo Medinipur district has 38 and 24 Parganas (south) has 21 landing centres (CMFRI, 2012).

According to the Marine Fisheries Census 2010, there were 95,283 active marine fishermen in West Bengal, of

Fig. 1. Map showing the maritime districts of West Bengal

whom 55,511were fulltime fishermen and 24,744 were part-time with the rest engaged in fish seed collection. Nearly 14,000 mechanised and 3,000 non-motorised crafts are in operation presently in the marine fishery sector of West Bengal during 2010 (CMFRI, 2012). A wide variety of gears are operated along the coast among which, gillnet, trawlnet and bagnet are the major ones. The total landings in the coast of West Bengal grew continuously from 2.29 lakh tonnes in 2007 to a maximum of 3.59 lakh tonnes in 2010. The increase in the landings may be attributed to the number and efficiency of the fishing craft and gear.

To ensure the long-term sustainability of fishery resources, it is essential that exploited stocks be regularly assessed and the results of these assessments incorporated in fishery management process (FAO, 2010). Furthermore the effective management and conservation of the ecosystems rely heavily on the understanding of spatial and temporal distributions of the fish community, ecological variables and fishing activity (Ferraroli *et al*., 2004). Fishing-induced changes on marine ecosystems have been documented using a variety of methods including multi-parametric analysis and diversity indices (Rochet and Trenkel, 2003). The information on landings for all species by commercial fisheries can facilitate an analysis of species diversity and distribution patterns.

Assessing biodiversity is one of the central issues in ecology because of its importance in devising conservation strategies. The species diversity has two distinct concepts: species richness and abundance. Species richness is the number of species in a community, while abundance explains the relative proportion of each species in the community (Gupta, 2010). Diversity indices are mathematical functions that combine richness and evenness in a single measure. Though there are several methods, the most commonly used diversity indices are Shannon's diversity index and Simpson's diversity index (Colwell, 2009). The Shannon's index stresses the evenness component, whilst the Simpson's index lays greater emphasis on the richness component (McGarigal and Marks, 1994; Riitters *et al.*, 2000). As a result, these indices can show considerable variation in their response to changes in species composition. The species diversity indicating a combination of species richness and species evenness can provide important information for assessing the spatio-temporal variability.

The present study was undertaken with the objective of assessment of the status of the marine fishery resources and estimation of diversity indices using the fish landings data along the coast of West Bengal, India.

Materials and methods

Database

The Central Marine Fisheries Research Institute has developed methodology for estimation of marine fish landings in India based on the Stratified Multistage Random Sampling scheme and has built up a large database of estimates of species wise and craft-wise marine fish landings along with the fishing effort expended (Srinath *et al.,* 2005). The data on estimated month-wise, gear-wise and species-wise marine fish landings were used for this study.

The Simpson's and Shannon's diversity indices were calculated from the season-wise estimated marine fish landings along the coast of West Bengal for assessing the diversity of fishery resources between 2007 and 2010. The indices were calculated using weight instead of numbers.

The Shannon's index (H') (Shannon and Weaver, 1949) is defined as follows.

$$H' = -\sum_{i=1}^{s} p_i \log_2 p_i$$

where p_i is the proportion of i^{th} species in the s^{th} category and s is the number of category.

Shannon's index is 0 if there is only one species, and is maximum when all s categories are equally represented.

The Simpson's index (Simpson, 1949) belongs to the category of dominance indices that attach more importance to abundant species. This index is defined as $\lambda = \sum_{i=1}^{s} p_i^2$ where p_i is the proportion of i^{th} species in the s^{th} category. The diversity is low if Simpson's diversity index is high. The calculated diversity indices among seasons were compared using one-way ANOVA, considering each season as a sample unit.

Results and discussion

The marine fish landings data collected from the various landing centres spread along the two coastal districts of West Bengal were analysed. The total landings was 3.59 lakh tonnes in 2010 which was slightly above the 2007–10 average of about 3.1 lakh tonnes. Among the prevailing gears, mechanised trawlnet, gillnet, bagnet and hooks and line accounted for more than 88% of total landings along the coast of West Bengal. Multiday operations of trawlers and gillnetters were regular phenomenon during the fishing season of July-February. The mechanised trawlers were operating in a depth zone ranging from 30 to 45 m spending about five to six days per trip. The mechanised gillnetters usaully stay away from the landing centres even upto eight days and operate in a

depth range of 30 to 40 m. The hand trawls were also recorded in the multiday fishing operations from 24 Parganas District. They operate only during October-December and spend about seven days per trip in the sea. The depth zone of fishing varied from 20 to 30 m. Shore seine and ring seine operations were also reported from this region.

Assemblage outline

The pelagic species constituted the bulk of the landings (about 57% in terms of weight) in West Bengal during 2007-10, followed by demersal species (29%). The crustacean group was far behind (13%). The contribution by mollusc group was negligible. There were 154 species of fish and shellfishes landed during this period, of which 65 were demersal, 59 pelagic and 21 crustacean. The maximum number of species of fish (107) belonging to 44 pelagic, 44 demersal, 17 crustacean and 2 mollusc species were landed during 2008. There was not much difference in the total number of species landed under pelagic, demersal, crustacean and molluscan groups from year to year (Fig. 2). Among the species landed, half of the pelagic and demersal species were frequently caught.

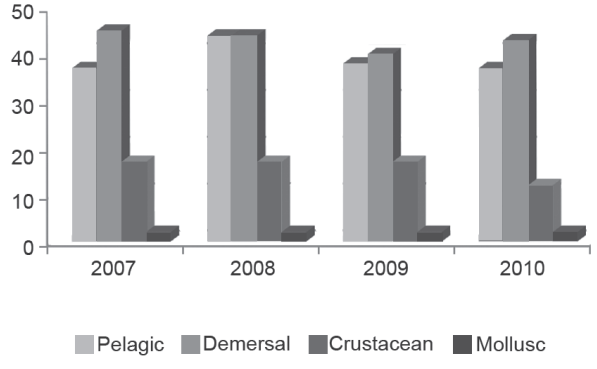

Fig. 2. Number of species landed during 2007-10

Resource-wise profile

The single most important species in terms of landings was hilsa shad (*Tenualosa ilisha*), with annual landings in the range of 48–83 thousand tonnes during 2007-10, accounting 19% of the total landings. The other important contributors to the total landings were Bombayduck (*Harpadon nehereus)* (12%), croakers (9.3%), penaeid prawns (6.8%), catfishes (5.7%), other clupeids (5.4%) and non-penaeid prawns (5.4%). The species contributing to croaker diversity were *Otolithes* spp., *Johnius* spp., *Protonibea diacanthus*, *Otolithoides biauritus*, *Johnieops* spp. and *Nibea maculata*. The penaeid prawn landings were constituted mainly by *Solenocera hextii*, *Metapenaeopsis stridulans*, *Metapenaeus affinis*, *Metapenaeus brevicornis*, *Metapenaeus monoceros*, *Metapenaeus dobsoni*, *Parapenaeopsis hardwickii*, *Parapenaeopsis stylifera*, *Parapenaeus* spp., *Penaeus canaliculatus*, *Penaeus indicus* and *Penaeus monodon*. The important species of catfish landed along West Bengal coast were *Arius thalassinus*, *Arius tenuispinis* and *Osteogeneiosus militaris*. The clupeid landings were represented by *Amblygaster leiogaster*, *Chirocentrus nudus*, *Stolephorus commersonii*, *Stolephorus indicus*, *Thryssa mystax*, *Thryssa dussumieri*, *Ilisha megaloptera*, *Opisthopterus tardoore*, *Raconda russeliana*, *Escualosa thoracata*, *Dussumieria acuta* and *Anodontostoma chacunda*. The major species contributing to the non-penaeid prawn landings were *Acetes* spp. and *Plesionika* spp.

Seasonal scenario

The season-wise marine fish landings showed considerable variations in this region. The fishing season begins by July and extends upto February. The most productive season was October to December (season 4) followed by July to October (season 3) and the lean season was from April to June (season 2) (Fig. 3). West Bengal government imposes a routine fishing ban during March to June. Hence the landings during season 1 (January to March) and season 2 come under the influence of seasonal closure. Apart from this, this region is cyclone prone and fishing operations are affected by cyclones and floods during June to September. Cyclones may also occur in May. Only two to three species were dominant in different seasons (Fig. 4). During seasons 4 and 1, the dominant species were Bombayduck, croakers and prawns. While in the third season, the dominant species were Hilsa shad followed by Bombayduck and croakers. Due to cyclonic weather conditions and strong wind in the second season, not much fishing operations were carried out and considered as the lean season with the main contributor as hilsa shad landed by gillnetters and bagnetters.

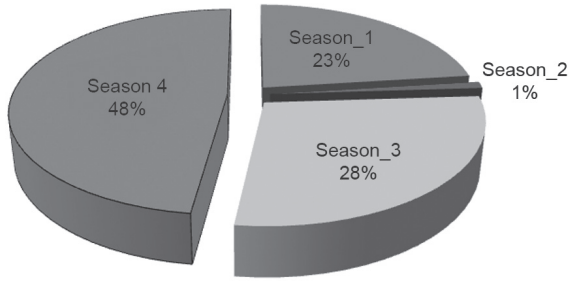

Fig. 3. Season-wise landings in West Bengal during 2007-10

The Shannon's and Simpson's indices were computed for all the seasons during 2007-10. The values of Shannon's index () were lower in second season in all the years (Fig. 5). The third season is significantly different from other seasons. The value ranged between 2.49 to 4.47, the lowest in third season of 2007 and highest in first season

Year	Dominent groups landed			
	Season 1	Season 2	Season 3	Season 4
2007	Bombayduck Non-penaeid prawns Croakers	Hilsa shad Silver pomfret *Coilia*	Hilsa shad Bombayduck Silver pomfret	Bombayduck Croakers Penaeid prawns
2008	Croakers Bombayduck Non-penaeid prawns	Croakers *Setipinna* Penaeid prawns	Hilsa shad Bombayduck Croakers	Hilsa shad Croakers Bombayduck
2009	Croakers Penaeid prawns Catfishes	Bombayduck Hilsa shad Croakers	Hilsa shad Bombayduck Croakers	Bombayduck Croakers Hilsa shad
2010	Bombayduck Croakers Penaeid prawns	Hilsa shad Bombayduck Sharks	Hilsa shad Penaeid prawns Bombayduck	Hilsa shad Bombayduck Penaeid prawns

Fig. 4. Dominant groups in the marine fish landings in West Bengal during 2007-2010

of 2009. The lowest value was mainly because of the contribution by single species, hilsa shad (59%) to the total landings.

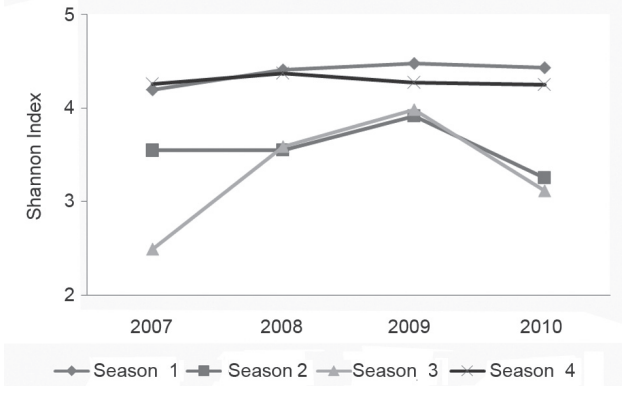

Fig. 5. Shannon's index for the different seasons

The values of Simpson's index varied from 0.06 to 0.37, the lowest in first season of 2009 and highest in third season of 2007 (Fig. 6). The ANOVA results indicated that the index has significant difference among the seasons with the third season significantly higher compared to other seasons. Simpson's index gives more importance to the abundant species. Hence the highest value was mainly because of the landings of single species, hilsa shad.

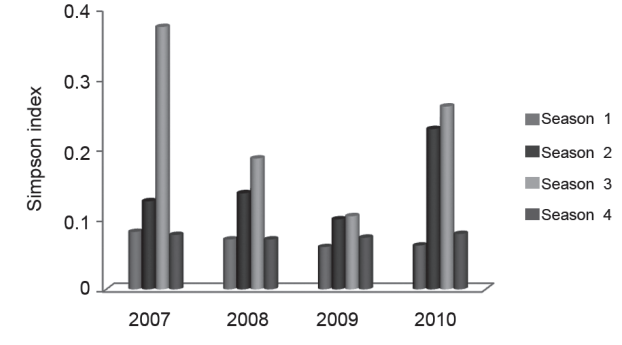

Fig. 6. Simpson's index for different seasons

Emphasising evenness, the Shannon's index suggests that the third season of 2007 is less diverse than the first season of 2009 (2.49 vs. 4.47, respectively). However, the Simpson's index, emphasising abundance, suggests that the third season of 2007 is the more diverse (0.37 vs. 0.06, respectively). An explanation of this divergence is provided by Peet (1974), who states that the Shannon's diversity index responds most strongly to changes in importance of the rarest species, while the Simpson's index responds most strongly to changes in the proportional abundance of the most common species. Here, Simpson index brings out the importance of the abundant species, the hilsa shad, during the third season. The abundance of the hilsa shad can be attributed to recruitment success, which is strongly driven by the hydrographic parameters in the sea as well as in the rivers, and spawning success in the rivers (Dwivedi and Choubey, 1998). According to Vivekanandan and Krishnakumar (2010), considering catch as a surrogate of abundance, the climate-driven fishery reflects the strength of the stocks and higher abundance results in higher catches of hilsa shad.

From the results of this study it can be concluded that there is species diversity among the seasons over the years. Since the commercial fisheries are species selective depending on factors such as craft, gear, effort and deployment depth, the landings data only represents the particular depth ranges covered by fishing crafts. Therefore the species diversity estimated in this study did not describe the diversity of all the marine fish fauna of West Bengal. However, this study throw light on the understanding of variability in the fish assemblages and diversity.

Acknowledgements

The authors profusely thank Dr. G. Syda Rao, Director, CMFRI for providing the facilities, support and guidance.

References

CMFRI 2012. *Marine Fisheries Census 2010 Part II(1) West Bengal*. Central Marine Fisheries Research Institute, Kochi, 199 pp.

Colwell, R. 2009. Estimate S: Statistical estimation of species richness and shared species from samples. Version 8.2. http:/ viceroy.eeb.uconn.edu/EstimateS

Dwivedi, S. N. 1993. Long term variability in the food chains, biomass yield and oceanography of the Bay of Bengal ecosystem. In: Sherman, K., Alexander, L. and Gold, B. D. (Eds). *Large Marine Ecosystems: stress, mitigation and sustainability*) Blackwell Publishing Co., p. 43-52.

Dwivedi, S. N. and Choubey, A. K. 1998. Indian Ocean Large Marine Ecosystems: Need for national and regional framework for conservation and sustainable development. *Large Marine Ecosystems of the Indian Ocean*, Blackwell Publishing Co., p. 361-368.

FAO 2010. *The state of world fisheries and aquaculture 2010*. FAO, Rome, 197 pp. www.fao.org/docrep/013/i1820e/ i1820e.pdf

Ferraroli, S., Georges, J. Y., Gaspar, P. and Le Maho, Y. 2004. Endangered species : Where leatherback turtles meet fisheries. *Nature,* 429: 521–522.

Gupta, A. C. 2010. A dynamic analysis for investigating the linkages between fish biodiversity and profitability. *Proceedings of the International Conference on Applied Economics*, p. 235-243.

McGarigal, K. and Marks, B. 1994. FRAGSTATS - Spatial pattern analysis program for quantifying landscape structure. V. 2.0. Oregon State University, Corvallis, Oregon, USA.

Peet, R. K. 1974. The measurement of species diversity, *Ann. Rev. Ecol. Syst*., 5 : 285–307

Reemtsma, T., Ittekkot, V., Bartsch, M. and Nair, R. R. 1993. River inputs and organic matter fluxes in the northern Bay of Bengal. *Chem. Geol.*, 103: 55-71.

Riitters, K. H., Wickham, J. D., Vogelmann, J. E., and Jones, K. B. 2000. National land-cover pattern data. *Ecology,* 81: 604 pp.

Rochet, M. J. and Trenkel, V. M. 2003. Which community indicators can measure the impact of fishing? A review and proposals. *Can J. Fish. Aquat. Sci.,* 60: 86–99.

Shannon, C. E. and Weaver, W. 1949. *The mathematical theory of communication*. University of Illinois Press, Urbana, USA,117 pp.

Simpson, E. H. 1949. Measurement of diversity. *Nature*, 163: 688 pp.

Srinath, M., Somy Kuriakose and Mini, K. G. 2005. *Methodology for estimation of marine fish landings in India.* CMFRI Special Publication, 57 pp.

Vivekanandan, E. and Krishnakumar, P. K. 2010. Spatial and temporal differences in the coastal fisheries along the east coast of India. *Indian J. Mar. Sci*., 39(3): 380-387.

Date of Receipt : 07.04.2012
Date of Acceptance : 27.12.2012